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FOR: RADIO FREQUENCY SWITCH AND WIRELESS COMMUNICATION APPARATUS USING THE SAME

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents
Washington, D.C. 20231
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I, the below named translator, hereby declare that:

1. My name and post office address are as stated below.

2. That I am knowledgeable in the English language and in the language of JP2000-237029, and I believe the attached English translation to be a true and complete translation of JP2000-237029.

3. The document for which the attached English translation is being submitted is a patent application on an invention entitled RADIO FREQUENCY SWITCH AND WIRELESS COMMUNICATION APPARATUS USING THE SAME.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so

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Date: April 28, 2005

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[NAME OF ARTICLE] Drawing 1

[NAME OF ARTICLE] Abstract 1

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[NAME OF THE DOCUMENT] Specification

[TITLE OF THE INVENTION] RADIO FREQUENCY SWITCH AND WIRELESS COMMUNICATION APPARATUS USING THE SAME

[CLAIMS]

[Claim 1] A radio frequency switch comprising: an antenna port; a transmission port; a reception port; a first diode connected in series to the transmission port; a low pass filter disposed between the first diode and the antenna port, the low pass filter having transmission band and reception band as passing band; a second diode connected between the reception port and the ground; and a high pass filter provided between the first diode and the reception port, the high pass filter having reception band as passing band, and having a phase shifting function so that an impedance as seen from the first diode to the reception port side is almost open in the transmission band when a current flows in the second diode.

[Claim 2] The radio frequency switch of claim 1, wherein the low pass filter and the high pass filter are formed of discrete-chip component composed of an inductor and a capacitor.

[Claim 3] The radio frequency switch of claim 1, wherein the low pass filter and the high pass filter are composed of an inductor and a capacitor formed in a dielectric substrate.

[Claim 4] The radio frequency switch of claim 2 or 3, wherein the low pass filter has a polarity property at frequency of about 2 times of transmission frequency.

[Claim 5] The radio frequency switch of claim 1, further comprising a high impedance inductor connected between the antenna port and the reception port for direct-current coupling of the first diode and the second diode.

[Claim 6] The radio frequency switch of claim 2 or 3, wherein the high pass

filter is configured in a form of a T type circuit composed of a first capacitor, a second capacitor connected in series to the first capacitor, and an inductor having one end grounded and connected in parallel to the first capacitor and the second capacitor.

[Claim 7] The radio frequency switch of claim 1, wherein the high pass filter has a polarity property.

[Claim 8] A wireless communication apparatus using the radio frequency switch of any of claims 1 to 7.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD TO WHICH THE INVENTION PERTAINS]

The present invention relates to a radio frequency switch usable in an antenna duplexer for transmission and reception switching in a wireless communication apparatus, and a wireless communication apparatus using the same.

[0002]

[BACKGROUND ART]

In a system for transmitting and receiving in time division, generally, an antenna duplexer is composed by using a switch. Examples of system of communication by time division include PHS (Personal Handy-phone System) of Japan and key-less entry system of an automobile, and the like. A conventional circuit configuration of the periphery of an antenna duplexer using a switch is shown in Fig. 2. In Fig. 2, reference numeral 101 denotes a transmission terminal, 102 denotes an antenna terminal, 103 denotes a reception terminal, 104 denotes a control terminal, 105 denotes a transmission power amplifier, 106 to 108 denote capacitors, 109 denotes an inductor, 110 denotes a current control resistance, 111 denotes a bypass capacitor, 112 denotes

a choke coil for cutting off radio frequency, 113, 115 denote diodes, 114 denotes a quarter wavelength ($\lambda/4$) transmission line at transmission frequency (λ means wavelength), 116 denotes a band pass filter such as a SAW filter, 117 denotes a low noise amplifier (LNA) for amplifying reception signal, and 118 denotes a mixer for converting frequency to intermediate frequency.

[0003]

In this configuration, capacitors 106 to 108 and inductor 109 compose a low pass filter. In particular, a parallel circuit of capacitor 108 and inductor 109 resonates at a frequency of about 2 times of the transmission frequency, and removes the harmonic components of power amplifier 105. Further, diodes 113, 115 and quarter wavelength transmission line 114 function as a switch for connecting antenna terminal 102 and transmission terminal 101 when a current flows from control terminal 104, and connecting antenna terminal 102 and reception terminal 103 when the current is cut off.

[0004]

Band pass filter 116 is inserted for the purpose of removing the undesired signal outside of the band, and preventing the occurrence of distortion in the LNA 117. Band pass filter 116 also removes image frequency component which becomes noise in the intermediate frequency component generated in mixer 118. For the convenience of image removing characteristic, the SAW filter is often used.

[0005]

[PROBLEM TO BE SOLVED BY THE INVENTION]

In this configuration, however, especially in a receiving pathway, since signal passes through the inserted quarter wavelength transmission line 114 and band pass filter 116 before it is input into LNA 117, the sensitivity deteriorates due to insertion loss of quarter wavelength transmission line 114

and band pass filter 116. When the quarter wavelength transmission line 114 and SAW filter are used, the insertion loss of band pass filter 116 is respectively about 0.5 dB and 3.5 dB, and the total loss may reach as high as about 4.0 dB on the assumption that they can be substantially configured in a wireless circuit.

[0006]

Therefore, in order to enhance the sensitivity further, it is required to decrease the insertion loss in the reception route from the antenna before input to the LNA, in particular. In other words, the decrease of the insertion loss is a key point for the performance improvement as a receiver.

[0007]

[MEANS FOR SOLVING PROBLEM]

Therefore, in order to solve these problems, the present invention includes an antenna port; a transmission port; a reception port; a first diode connected in series to the transmission port; a low pass filter disposed between the first diode and the antenna port, the low pass filter having transmission band and reception band as passing band; a second diode connected between the reception port and the ground; and a high pass filter provided between the first diode and the reception port, the high pass filter having reception band as passing band, and having a phase shifting function so that an impedance as seen from the first diode to the reception port side is almost open in the transmission band when a current flows in the second diode. Thus, the expected purpose is achieved.

[0008]

[MODE FOR CARRYING OUT THE INVENTION]

The radio frequency switch described in claim 1 includes an antenna port; a transmission port; a reception port; a first diode connected in series to

the transmission port; a low pass filter disposed between the first diode and the antenna port, the low pass filter having transmission band and reception band as passing band; a second diode connected between the reception port and the ground; and a high pass filter provided between the first diode and the reception port, the high pass filter having reception band as passing band, and having a phase shifting function so that an impedance as seen from the first diode to the reception port side is almost open in the transmission band when a current flows in the second diode.

[0009]

According to the above-mentioned configuration, harmonic components of the output amplifier causing problems particularly at the transmission side can be removed, and undesired signals outside of the reception band can be removed efficiently while decreasing the loss in the reception side route, and therefore a radio frequency switch realizing a more excellent wireless characteristic can be obtained.

[0010]

The radio frequency switch described in claim 2 is the radio frequency switch of claim 1, wherein the low pass filter and the high pass filter are formed of discrete-chip component composed of an inductor and a capacitor.

[0011]

According to the above-mentioned configuration, a radio frequency switch that can be composed as a module mounted on a substrate and in which elements can be extremely easily replaced individually in manufacture.

[0012]

The radio frequency switch described in claim 3 is the radio frequency switch of claim 1, wherein the low pass filter and the high pass filter are composed as a pattern of an inductor and a capacitor formed in a dielectric

substrate.

[0013]

According to the above-mentioned configuration, for example, by using a low temperature co-fired ceramics (LTCC) substrate, the circuit can be integrated in the laminate structure, and further by using silver or copper of small conductor loss in the inner layer electrode material, a radio frequency switch of smaller size, lower height and smaller loss can be realized.

[0014]

The radio frequency switch described in claim 4 is the radio frequency switch of claim 2 or 3, wherein the low pass filter has a polarity property at frequency of about 2 times of transmission frequency.

[0015]

According to the above-mentioned configuration, 2 times of harmonic frequency from transmission amplifier, which causes particularly a serious problem, can be removed efficiently by using fewer elements.

[0016]

The radio frequency switch described in claim 5 is the radio frequency switch of claim 1 further comprising a high impedance inductor connected between the antenna port and the reception port for direct-current coupling of the first diode and the second diode.

[0017]

According to the above-mentioned configuration, since the first diode and the second diode are direct-current connected, each diode is not required to be provided with a control terminal. Therefore, a radio frequency switch of smaller size can be realized.

[0018]

The radio frequency switch described in claim 6 is the radio frequency

switch of claim 2 or 3, wherein the high pass filter is configured in a form of a T type circuit composed of a first capacitor, a second capacitor connected in series to the first capacitor, and an inductor having one end grounded and connected in parallel to the first capacitor and the second capacitor.

[0019]

According to the above-mentioned configuration, when L-C-L is connected in P-type, since the diode and L are connected in parallel, a radio frequency switch capable of avoiding the inconvenience of uncontrollability caused by inflow of direct control current for diode switching.

[0020]

The radio frequency switch described in claim 7 is the radio frequency switch of claim 1, wherein the high pass filter has a polarity property.

[0021]

According to the above-mentioned configuration, by allowing the image frequency in a mixer connected in the later stage of the reception side, for example, to have a polarity property, a radio frequency switch capable of reducing the number of components and having a smaller size as the entire reception circuit can be realized.

[0022]

The radio frequency switch described in claim 8 is a wireless communication apparatus using the radio frequency switch of any of claims 1 to 7.

[0023]

According to the above-mentioned configuration, a wireless communication apparatus capable of, in the entire wireless communication apparatus, downsizing the circuit configuration, reducing the number of components and having a smaller size and lower cost can be realized.

[0024]

Hereinafter, an embodiment of the present invention is described with reference to drawings.

[0025]

Fig. 1 shows a radio frequency switch in an embodiment of the present invention in which reference numeral 1 denotes a transmission terminal, 2 denotes an antenna terminal, 3 denotes a reception terminal, 4 denotes a control terminal, 5 denotes a transmission amplifier, 6 denotes a current control resistance, 8, 13, 16, 18 denote inductor elements, 7, 10, 11, 12, 14, 15, 17, 20 denote capacitor elements, 9, 19 denote diodes, 21 denotes an LNA, 22 denotes a SAW filter, and 23 denotes a mixer.

[0026]

When a positive voltage is applied to control terminal 4, a current limited by current control resistance 6 flows in diode 9, inductor 18 and diode 19, and diodes 9, 19 are turned ON. The high frequency impedance of inductor 18 is a sufficiently large value. For example, at 900 MHz, the inductance is about 100 nH or more. A T-type circuit composed of capacitors 15, 17 and inductor 16 is matched with the system impedance (usually 50 ohms), and is a phase shifting circuit of HPF type is formed. In order that the impedance as seen from A to right side may be in an open in an ON state of diode 19, values are determined.

[0027]

Therefore, when the diodes are in an ON state, the transmission terminal 1 and antenna terminal 2 are connected, and when the diode is OFF, antenna terminal 2 and reception terminal 3 are connected. That is, they function as a radio frequency switch circuit. Capacitors 14, 20 are DC cut-off elements. Capacitor 7 is a bypass capacitor and inductor 8 is a choke element.

[0028]

Further, capacitors 10, 11, 12 and inductor 13 compose a notched p-type LPF. The notch characteristic is introduced by a parallel circuit of inductor 13 and capacitor 10. In the wireless communication system, from transmission amplifier 5, in particular, harmonic distortion of 2 times of transmission frequency is a serious problem, and hence the frequency of the notch is set at 2 times of the transmission frequency. As a result, higher performance wireless circuits can be realized.

[0029]

In the above-mentioned configuration, in a path from transmission terminal 1 to antenna terminal 2, the transmission signals can be efficiently filtered by the notched LPF composed of capacitors 10, 11, 12 and inductor 13 to be deprived of undesired signal components. On the other hand, in a path from antenna terminal 2 to reception terminal 3, a BPF is equivalently formed by the notched LPF composed of capacitors 10, 11, 12 and inductor 13 and the HPF composed of capacitors 15, 17 and inductor 16.

[0030]

Usually, when an undesired large signal is fed from the antenna directly into LNA 21, LNA 21 is distorted, and stable communication cannot be maintained. Therefore, generally, a BPF is inserted between the antenna and LNA 21. The most remarkable characteristic of the configuration of the present invention is that the BPF necessary in the preceding stage of LNA 21 is composed by combining the LPF for removing higher harmonics for transmission and the HPF composed of a phase shifting circuit, and thereby the loss is lowered (the reception sensitivity is enhanced) and the small size and low cost are realized at the same time.

[0031]

Furthermore, removal of image frequency component which matters in mixer 23 is enabled by the SAW filter 22 connected in the later stage of LNA 21. Further, by connecting an inductor newly parallel to capacitor 15 or 17, or by connecting a capacitor newly in series to inductor 16, a notched HPF may be composed, so that the image frequency may be removed more widely by its notch characteristic.

[0032]

In the embodiment, instead of SAW filter 22, for example, a filter using a dielectric or an LC filter may be employed.

[0033]

The capacitors and inductors shown in the embodiment may be composed by using chip components, and therefore if properties are not uniform in manufacture, elements can be replaced individually, and this circuit can be easily composed as a module mounted on a substrate.

[0034]

Moreover, the circuit elements shown in the embodiment may be formed as a pattern composed in a dielectric substrate. In this constitution, for example, by using a low temperature co-fired ceramics (LTCC) substrate, the circuit can be integrated in the laminate structure, and further by using silver or copper of small conductor loss in the inner layer electrode material, a radio frequency switch of smaller size, lower height and smaller loss can be realized.

[0035]

[EFFECT OF THE INVENTION]

Thus, according to the present invention, harmonic components of the output amplifier causing problems particularly at the transmission side can be removed, and the undesired signals outside of the reception band can be removed efficiently while decreasing the loss in the reception side route, and

therefore a radio frequency switch realizing a more excellent wireless characteristic can be obtained.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 shows a circuit configuration in an embodiment of the present invention.

Fig. 2 shows a circuit configuration in a prior art.

[Explanation of letters or numerals]

1 transmission terminal

2 antenna terminal

3 reception terminal

4 control terminal

5 transmission amplifier

6 current control resistance

8, 13, 16, 18 inductor element

7, 10, 11, 12, 14, 15, 17, 20 capacitor element

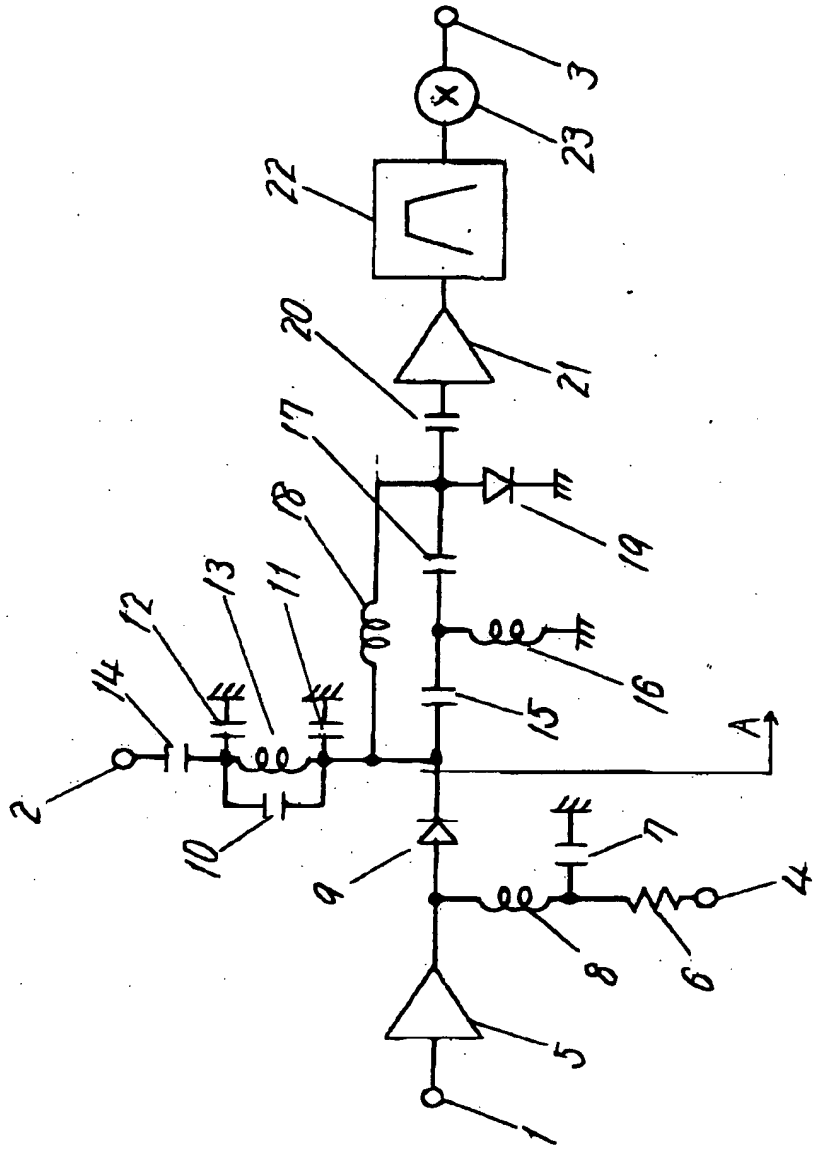
9, 19 diode

21 LNA

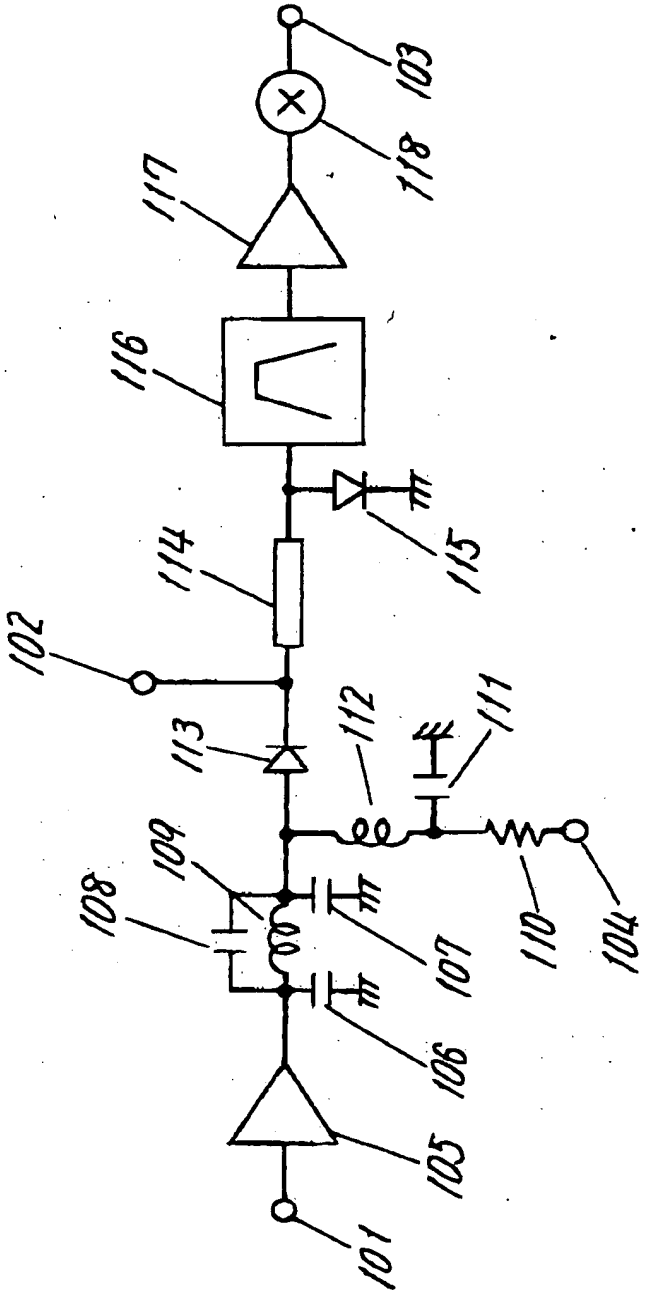
22 SAW filter

23 mixer

[Name of the Document] Drawings
[Fig. 1]



[Fig. 2]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[NAME OF THE DOCUMENT NAME] Abstract

[ABSTRACT]

[Problem] The present invention has an object to realize a radio frequency switch in which harmonic components of an output amplifier causing problems particularly at the transmission side can be removed, and undesired signals outside of a reception band can be removed efficiently while decreasing the loss in a reception side route.

[Means for solving problem] A first diode is connected in series to a transmission port, and a low pass filter having transmission band and reception band as passing band is disposed between the first diode and an antenna port. A second diode is connected between the reception port and the ground. A phase shifting function is provided between the first diode and a reception port, having reception band as passing band, so that the impedance as seen from the first diode to the reception port side is almost open in the transmission band when a current flows in the second diode.

[Selected Drawing] Fig. 1